Modern Healthcare Starts with Electricity

On-the-ground Insights from Goma, the Democratic Republic of Congo
Written by Jess Kersey, Samuel Miles, and Gina Cady

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Inesse, a lab technician in a community clinic, inspects a patient's culture for signs of infection. Even in facilities that are open 24/7, electricity cuts or insufficient storage capacity mean that many labs can only operate during the day when natural lighting can be used to backlight microscopes. Photo Credit: Jess Kersey.

> *French version*

Electricity is essential to modern healthcare. Perhaps nowhere is this more keenly felt than in Goma — the capital of the Democratic Republic of the Congo's (DRC) North Kivu province — where armed conflict has persisted through more than three decades of state and non-state organized violence across the African Great Lakes region.

In recent years, Goma's health facilities have struggled to meet the needs of a population that has rapidly expanded with the arrival of over 600,000 people displaced by the advancement of the M23 rebel group's 2022 resurgence.

Further complicating the situation is a chronic lack of reliable and high-quality electricity across the 838 health facilities of the province.

A lab technician inspects an x-ray. The radiology team at this hospital averages 50–60 x-rays per day, most to check the progression of tuberculosis. Photo Credit: Jess Kersey.

> "Electricity in the area [Zone de Santé] is almost non-existent…our facilities are equipped with ultrasound, x-rays, radiography, ECGs, and autoclaves for sterilization, but we cannot use these devices since we do not have an energy source capable of operating them." — Area Chief Doctor [Médecin-Chef de Zone]

Health facilities rely on electrical appliances for a variety of essential services — outages and periods of voltage fluctuation can be a question of life or death. Oxygen concentrators provide essential support for emergency resuscitation, heart conditions, and respiratory issues. During emergency and routine surgery, electricity sustains anesthesia, patient monitoring, and many other critical life-support functions. Laboratory equipment requires electricity for everything from blood testing, inspecting cultures, and performing ultrasounds to operating microscopes.

An absence of reliable power forces health facilities to depend on fossil fuels, biomass, and manual labor as alternative energy sources. For example, a common workaround for sterilizing medical instruments (a task usually done by an electric autoclave) is to use a "casserole à pression" — a charcoal pressure cooker.

Generators are another common back-up system, but these are expensive and polluting solutions. For example, at one hospital in Oicha, a highly populated but isolated, gridless city, the cost of diesel for back-up generators routinely averages 3,000 USD per month. A 2024 Power Africa cost benefit analysis found that outfitting health facilities in sub-Saharan Africa with photovoltaic systems is twice as cost-effective to addressing electrical grid outages compared to using diesel generators.

Left: Madame Jeanine scrubs medical instruments by hand. Manual labor replaces many tasks that are normally performed by electric appliances. Her request was for a washing machine to make the daily tasks of hand-washing sheets and medical linens easier. Right: Issa, a technician at a health facility with 95 beds in peri-urban Goma, shows the generator that is used to power the operating room during emergency c-sections. Photo Credit: Jess Kersey

“We have nurses that are using the flashlights from their phones to insert IVs during outages,” says Gaston Lumambo, Chief Doctor of the North Kivu Health Department. Many “workarounds” like these can introduce cross-contamination into the treatment rooms.

Behind the curtain are a team of hardworking electricians and technicians responsible for directing limited electricity flows to where they are most needed. Technicians are responsible for keeping power on as much as possible. This includes manually switching several times a day between different power sources like grid connections, solar panels, or generators to respond to the facility's needs while minimizing energy costs.

Particularly for facilities without back-up systems, technicians must triage needs and make decisions about how to redirect scarce electricity. In many hospitals, this is done manually — if an emergency operation is needed a surgeon will call the technician to redirect electricity from the maternity ward, laboratory, or administration.

Research by the University of California, Berkeley and a Goma-based non-governmental organization (NGO), Research Center for Humanitarian Aid (RCHA-RDC ABSL), in partnership with the Ministry of Public Health and the Autorité de Régulation du Secteur de l'Electricité (ARE, DRC's electricity sector regulator), has demonstrated just how dire the quality of electricity supply is. With support from Power Africa's Health Electrification and Telecommunications Alliance, and in partnership with private sector partner OffGridBox, the team has deployed solar kits at ten priority sites in remote and isolated health zones across the country and over 50 nLine sensors across 25 facilities in North Kivu. The team found that some grid-connected health facilities experienced as much as nine hours of outages each day. In terms of voltage, one facility's electricity supply was outside of a tolerated range (±10% of nominal voltage of 230 volts) for more than 21 hours per day on average resulting in limiting the ability to use vital medical equipment and impact lighting.

Technicians install inverters at a clinic in Mbuji-Mayi, Kasai Oriental province. The standalone systems consist of an average of three inverters with a total capacity of 6 kVA, 8.1 kWp of solar generation, and 30 kWh of battery storage capacity. In this facility the system will power the maternity ward, the operating room, the intensive care unit, the administrative office, and a new electric water purification system. Photo Credit: RCHA

These trends, and their impacts on healthcare provision, have largely been invisible under many of the current standards used by the electrification and health communities. Historically, electricity in hospitals has been measured through a recall-based survey questionnaire that rests on a threshold for "reliability" defined as an outage lasting longer than two hours. The ability of this measurement framework to give meaningful insight on the quality of electricity supply is limited given that, for example, patients under anesthesia for critical care operations may die without on-demand oxygen in under ten minutes.

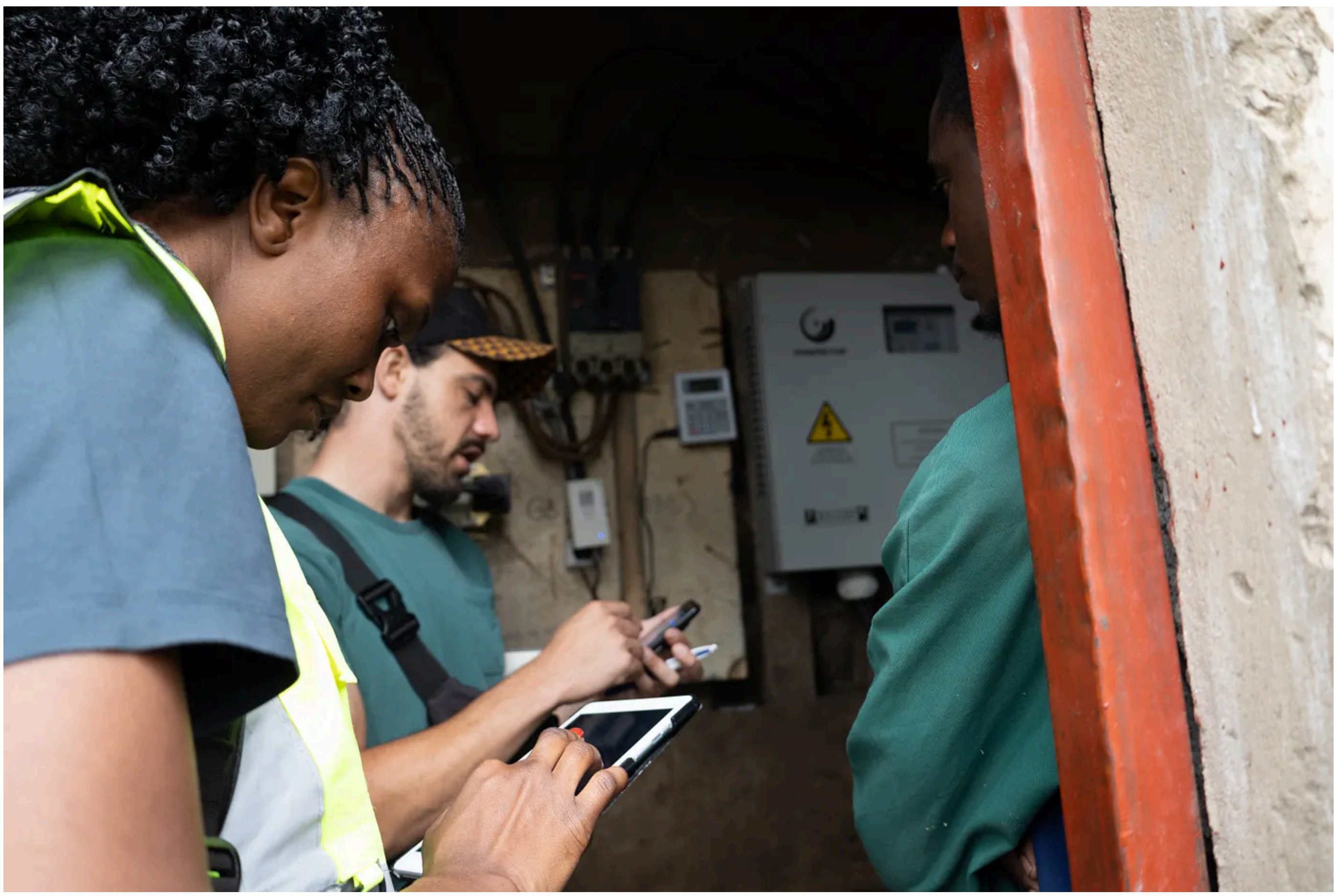
Solutions exist.

The potential for renewable, decentralized energy systems to revolutionize healthcare in the DRC and across low-resource communities globally is enormous. Synergies between electricity and digital monitoring solutions offer the opportunity for a virtuous cycle where energy services directly support the basic provision of modern health services, while leveraging the power of data analytics for leapfrogging legacy systems. This could touch every aspect of health provision, from customer intake to post-treatment follow-up and patient billing.

Jackson Mughuma, Executive Director of RCHA, poses with a PowerWatch sensor developed by nLine, Inc, installed at one of only four hospitals in Goma capable of producing medical oxygen. Photo by Jess Kersey.

The consortium of partners now aims to expand this approach, premised around participation, research, action, and advocacy, to 100 health facilities in North Kivu province to demonstrate the model's scalability.

In addition, Power Africa's Health Electrification and Telecommunications Alliance (HETA) has a goal to connect 10,000 health facilities in sub-Saharan Africa to help drive a market solution and improve health infrastructure and service delivery. HETA is unique among Power Africa programs in its scope and in its close ties to global health priorities. This lets HETA tap into a diverse network of co-funders, implementing partners, thought leaders, and constituents from the public and private sectors — including USAID champions from many parts of the Agency.



Divine Pembele of ARE administers a survey to a health facility technician. This survey is the first step in deploying a sensor at a new site. The involvement of the Regulatory Authority of the Electricity Sector (ARE) with UC Berkeley since August 2023 on improving the quality of electricity in healthcare facilities in North Kivu demonstrates essential buy-in and a clear commitment to lead electricity providers in the DRC with support in implementing corrective measures that demonstrate improvements in the reliability and quality of electricity for all, beginning with critical facilities. Photo Credit: Jess Kersey

“We have the opportunity to show that energy is the source of every aspect of development. My vision is to not only provide energy through sustainable economic models in all health facilities in areas without electricity in the Democratic Republic of the Congo, but also for households via mini-grids in order to promote overall community health and resilience,” says Jackson Mughuma, Executive Director of RCHA.

This private-public-NGO partnership model, if successful, will demonstrate an investment-ready implementation vision for sustainable financing systems capable of providing reliable, high-quality electricity to hundreds of thousands of health facilities in low-resource geographies currently operating in the dark.

Learn more about Power Africa‘s work to electrify health facilities

Learn more about Power Africa’s work in the Democratic Republic of the Congo

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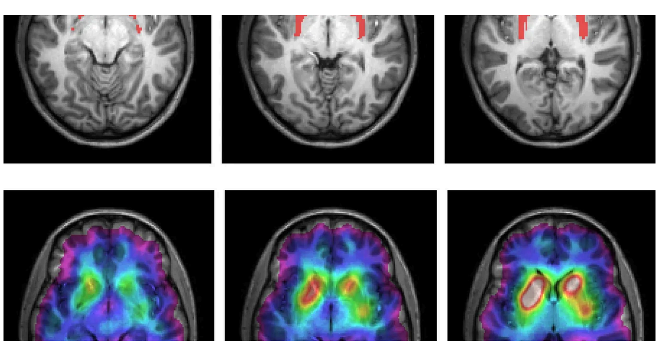

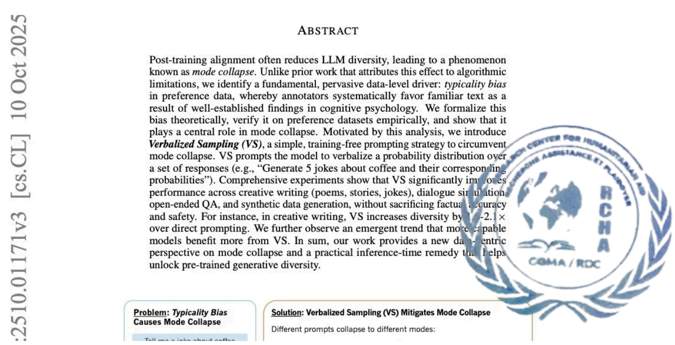
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ABSTRACT

Post-training alignment often reduces LLM diversity, leading to a phenomenon known as *mode collapse*. Unlike prior work that attributes this effect to algorithmic limitations, we identify a fundamental, pervasive data-level driver: *typicality bias* in preference data, whereby annotators systematically favor familiar text as a result of well-established findings in cognitive psychology. We formalize this bias theoretically, verify it on preference datasets empirically, and show that it plays a central role in mode collapse. Motivated by this analysis, we introduce ***Verbalized Sampling (VS)***, a simple, training-free prompting strategy to circumvent mode collapse. VS prompts the model to verbalize a probability distribution over a set of responses (e.g., "Generate 5 jokes about coffee and their corresponding probabilities"). Comprehensive experiments show that VS significantly improves performance across creative writing (poems, stories, jokes), dialogue simulation, open-ended QA, and synthetic data generation, without sacrificing factual accuracy and safety. For instance, in creative writing, VS increases diversity by 1.6-2.1× over direct prompting. We further observe an emergent trend that more capable models benefit more from VS. In sum, our work provides a new data-centric perspective on mode collapse and a practical inference-time remedy that helps unlock pre-trained generative diversity.

Problem: ***Typicality Bias* Causes Mode Collapse**

Solution: **Verbalized Sampling (VS) Mitigates Mode Collapse**

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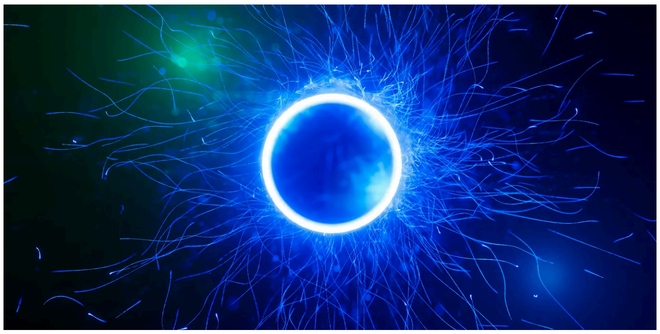

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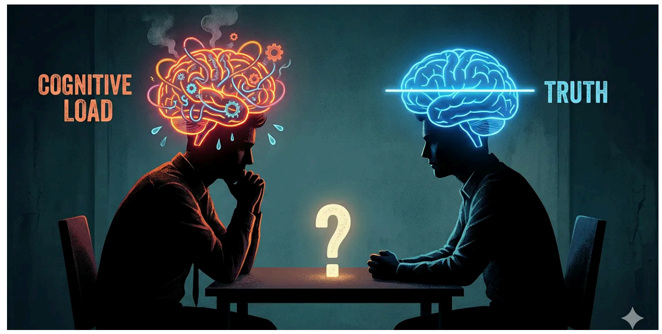

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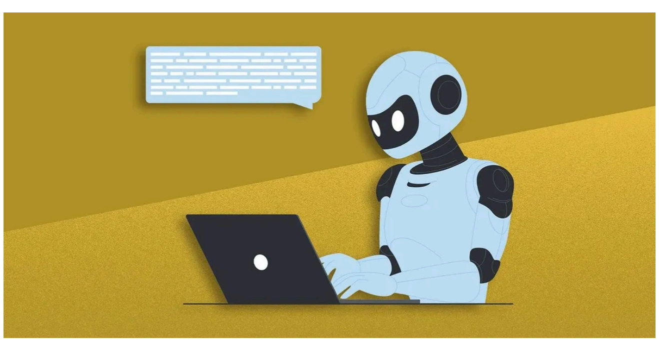

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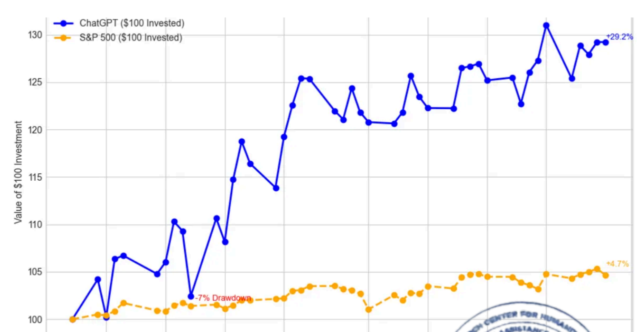

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